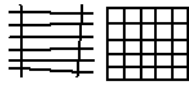
Other useful interpretation techniques (C05)

Top

An important part of the interpretation process is identifying and analysing anomalies and regional structure in magnetic survey data. INTREPID can make this task easier by enhancing the features you wish to examine.

This chapter summarises INTREPID enhancement methods.

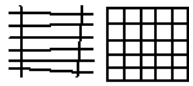
The next chapter, Presenting regional depth and structure data (C06) shows you the best ways to display your interpretation data.



For an explanation of the dataset and domain symbols, which appear frequently in this chapter, see "Symbols for INTREPID dataset types and domains" in Using INTREPID Cookbooks (R19).

Enhancement methods

Pass, continuation and directional filters

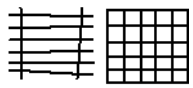


Pass and continuation filters are traditional aids to interpretation. They can remove ranges of wavelengths from the data, enhancing the features at depths characterised by the remaining wavelengths.

Directional filters enhance features in certain directions *(grid datasets only)*.

INTREPID tools: Line Filter, Spectral Domain Grid filters, Spatial Convolution filters.

Vertical gradient



The vertical gradient is another traditional interpretation aid. It can sharpen and enhance shallow source anomalies and the edges of anomalies. It can be used in combination with Automatic Gain Control (AGC). Start by using the default settings for the AGC filter in the Line Filter tool.

Another useful INTREPID feature is the ability to calculate fractional vertical derivatives, for example the 1.5 derivative.

INTREPID tools: Line Filter, Spectral Domain Grid filters.

Reference: Gunn, Maidment and Milligan, 1997.

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Analytic signal

The analytic signal can sharpen and enhance regional structure and the edges of anomalies in a grid. It has the advantage, particularly in low latitudes, that it does not require reduction to the pole.

INTREPID tools: Grid FFT tool (**gfilt.exe**), Euler Deconvolution tool (**euler.exe**).

Reference: Roest, Veroef and Pilkington, 1992.

Magmage coherence map

The MagMage coherence map detects discontinuities in a grid. We have found it useful for mapping peaks and troughs of magnetic trends. It has been able to identify weak magnetic axes and troughs that often only show up in vertical gradient images.

INTREPID tool: MagMage magnetic interpretation. (Under Interpretation - Magnetics)

Reference: Bahorich and Farmer, 1995; Gunn et al, 1997.

Hilbert complex wave products

Theory

The Hilbert transform is commonly used in seismology. It obtains an imaginary component of data. The imaginary component is similar to the real component in shape but is phase-shifted.

If you combine the two signals in complex space you obtain a signal which can be visualised as being in the shape of a spiral (see below).

The complex wave C is the sum of the real and imaginary waves (R and I)

C = R + I

At any point on the curve,

c = r + i

The **complex amplitude** a is the distance from the x axis to the point on the curve

Note: In some earlier editions of INTREPID spatial and time domain filters and transformations (R13) the complex amplitude is erroneously called the analytic signal.

$$a = \sqrt{r^2 + i^2}$$

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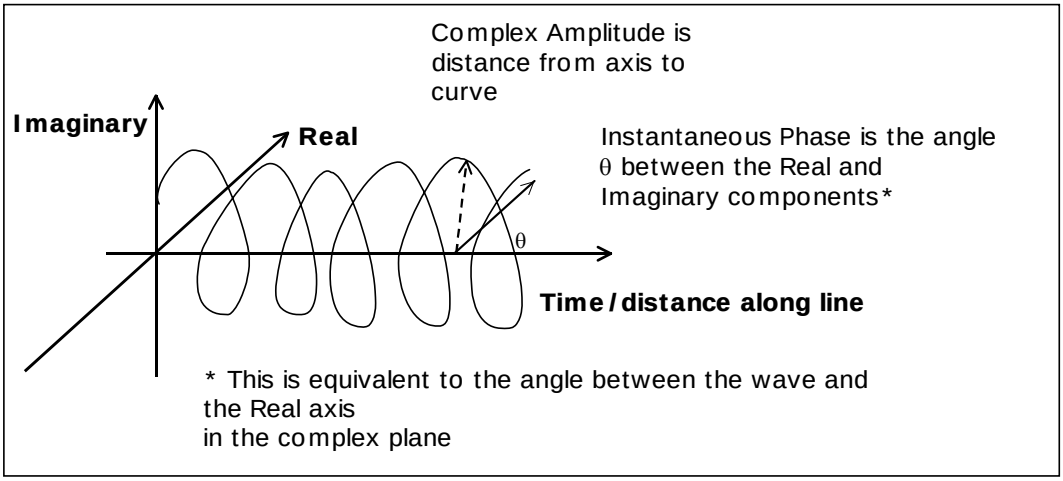
The **instantaneous phase** is the angle between the real and imaginary component.

$$\text{instantaneous phase} = \text{atan}\left(\frac{i}{r}\right)$$

The **instantaneous frequency** is the rate of change of instantaneous phase.

INTREPID uses its diff1( ) function to calculate this (See "INTREPID Functions" in INTREPID expressions and functions (R12) for details)

Inst Frequency = diff1 (Inst Phase)


Complex Amplitude is distance from axis to curve
Imaginary
Real
Instantaneous Phase is the angle θ between the Real and Imaginary components*
θ
Time / distance along line
* This is equivalent to the angle between the wave and the Real axis in the complex plane

Complex amplitude

You can use complex amplitude to enhance edges of anomalies. Its advantage is its ability to remove the dipolar effect of a magnetic anomaly.

INTREPID tool: Line Filter

Reference: Taner, Koehler and Sheriff, 1979

Instantaneous frequency

The instantaneous frequency product sharpens edges of anomalies, enhancing peaks and troughs

INTREPID tool: Line Filter

Reference: Taner, Koehler and Sheriff, 1979

Notes

Try these filters if you want to enhance deep low frequency structure. Run the filter and grid the resulting field. This grid can be useful as an image backdrop for depth method results such as Phillips, Euler or Naudy Automatic Model.

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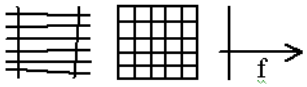
Tips for using enhancement methods

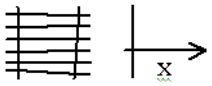
Enhancing regional magnetic structure

Accentuating magnetic structure

We recommend the following products for accentuating structure.



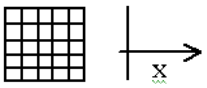
- First vertical derivative (or a fractional vertical derivative of order close to 1) followed by Automatic Gain Control (AGC). For gridded data, the spatial CNorm (contrast normalisation) filter has a similar effect to an AGC filter.



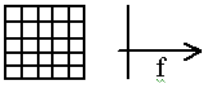
- Complex amplitude

Enhancing structure in certain directions

We recommend the following processes for accentuating structure in certain directions.



- Spatial convolution using, for example, the **`North_South`** or **`East_West`** kernel. You can also configure your own kernels. Contact our technical support service for assistance if required.



- Directional spectral domain filters: directional pass and directional cosine.

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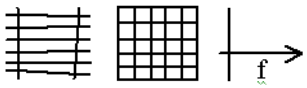
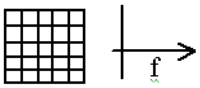
Enhancing edges of anomalies

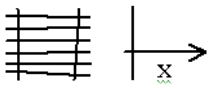
We recommend the following processes for showing the edges of anomalies.



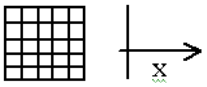
- First vertical derivative (or a fractional vertical derivative of order close to 1) followed by Automatic Gain Control (AGC).



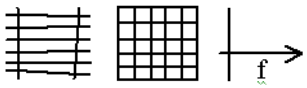
- Analytic signal



- Instantaneous frequency



- MagMage coherence map

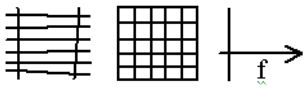


- Horizontal derivative

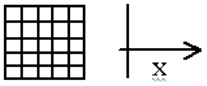
Enhancing features at different depths

Enhancing features deeper than 200 m

We recommend the following processes.



- Low pass filter (Butterworth filter for grids). Set it to pass wavelengths corresponding to depths greater than 200 m.



- Spatial convolution upward continuation grid filters, for example, **`up_cont_1`** and **`up_cont_2`**. These kernels perform upward continuation of one and two cell widths respectively.

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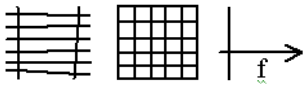
Removing very near surface sources

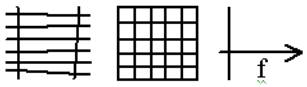
It is often desirable to remove sources which are very close to the surface (50 m below ground or shallower), for example, buildings and laterite deposits.

Apparent shallow sources can also simply be noise.

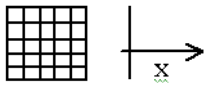
We recommend the following processes



- Upward continuation filter



- Low pass filter (Butterworth filter for grids)



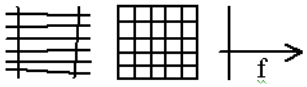
- Spatial convolution upward continuation grid filters, for example, **`up_cont_1`** and **`up_cont_2`**. These kernels perform upward continuation of one and two cell widths respectively.

Enhancing shallow sources

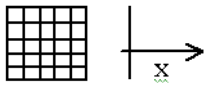
We recommend that you perform these processes on the line data before gridding. The gridding process tends to remove high frequency data, which may have value.

The processes will work on grids, however, if required.

We recommend the following processes.



- Vertical derivative of order 0.5–1.5
- AND High pass filter (Butterworth filter for grids)
- AND Downward continuation



- Spatial convolution high pass kernels, **`residual_1`** and **`residual_2`**

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Enhancing very shallow sources (strand line enhancement)

This method enhances strand lines up to 10 m below ground. The main purpose of this process is to locate heavy mineral sands or laterite.

Due to the prevalence of noise at this level and other difficulties, the process needs some expertise. We recommend that you refer to the reference paper (Mudge, 1991) before trying it. If you are unsure about parameters, contact our technical support service for advice.

Perform the following processing on line data (not gridded data).

Method 1:

- Apply a light low pass filter to remove high frequency noise. This is available in the Line Filter tool. For noisy data a 7-point moving average filter would be suitable.
- Calculate the horizontal derivative with order in the range 1–4 depending on the data. This is available in the Line Filter tool.

Method 2:

- Apply a light low pass filter to remove high frequency noise.
- Calculate the nth difference for the data. This is available using the diffn( ) function in the Spreadsheet Editor. Select an order for the diff function (e.g., diff4( )), depending on the data.
- Either apply an Automatic Gain Control (AGC) filter to the data (using the Line Filter tool), or take the square root of the data (using the sqrt( ) function in the Spreadsheet Editor).

See "Illustrating linear low amplitude high frequency data (strand line enhancement)" in Presenting regional depth and structure data (C06) for details about displaying the results of the process.

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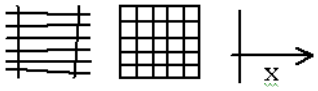
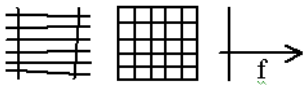
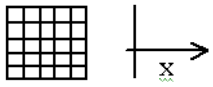
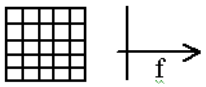
Reference Manual sections relevant to this chapter

While reading this chapter, you may need to refer to the following chapters.

	Chapter	Topic
	INTREPID spatial and time domain filters and transformations (R13)	General information about spatial and time domain filters for both line and grid datasets.
	INTREPID spectral domain operations reference (R14)	General information about spectral (Fourier) domain filters for both line and grid datasets.
	Line Filtering (T31)	Applying filters to line data in both the spectral and spatial domain.
	Spatial Convolution Grid Filters (T34)	Applying convolution kernel filters to grid data in the spatial domain.
	Old spectral domain grid filters (OldGridFFT) (T38)	Applying spectral (Fourier) domain filters to grid datasets.

You may also need to refer to "INTREPID Functions" in INTREPID expressions and functions (R12) and Spreadsheet Editor (T15).

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